Navy COAMPS-TC Update

James D. Doyle[1], Jon Moskaitis[1], Will Komaromi[1], Sue Chen[1],
Hao Jin[1], Yi Jin[1], Carey Dickerman[2]
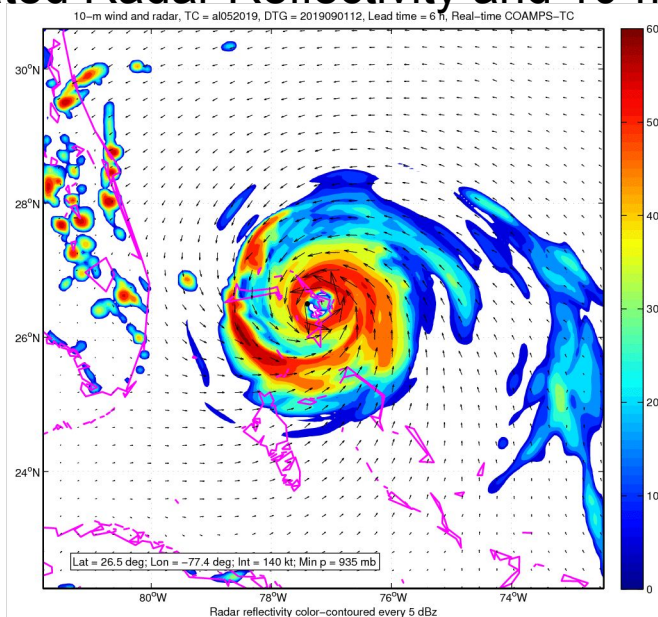[1]Naval Research Laboratory, Monterey, CA
[2]Fleet Numerical Meteorology and Oceanography Center
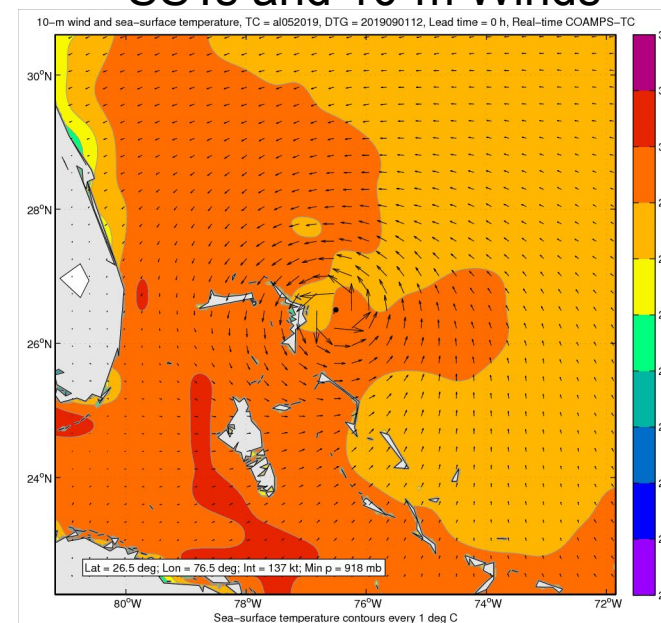
COAMPS-TC
System overview

- COAMPS-TC is a specialized version of the Navy's mesoscale numerical weather prediction (NWP) model, COAMPS, designed to predict tropical cyclone (TC) track, intensity and structure (wind radii)
- Features: TC-following nested grid meshes (4 km on inner mesh, 40L)
    Specialized TC physics (Drag coefficient; boundary layer); TC Vortex initialization
    Coupled with NRL Coastal Ocean Model, NCOM
- Operational at Navy FNMOC: i) deterministic NAVGEM BCs (**COTC**) and NOAA GFS BCs (**CTCX**)
                ii) COAMPS-TC ensemble (11 member, 4 km resolution) based on NOAA GFS

Dorian (05L) (12Z 1 Sep 2019)
Simulated Radar Reflectivity and 10-m Winds

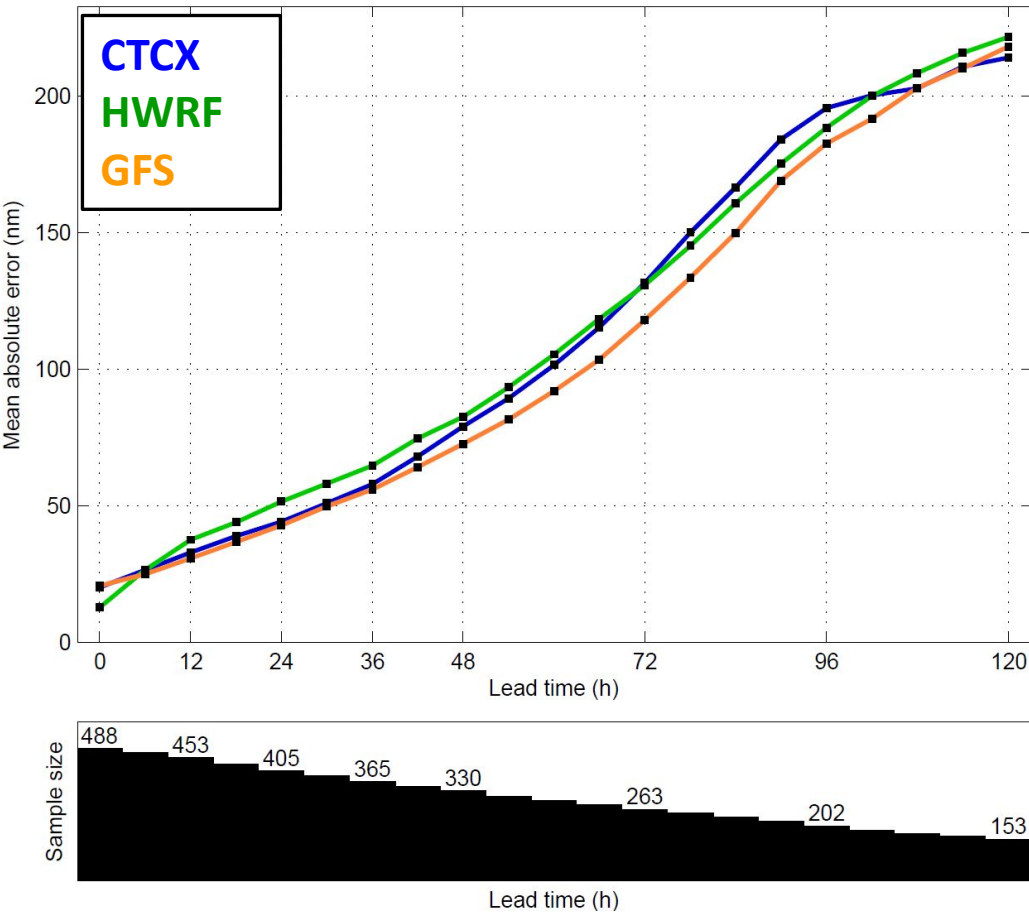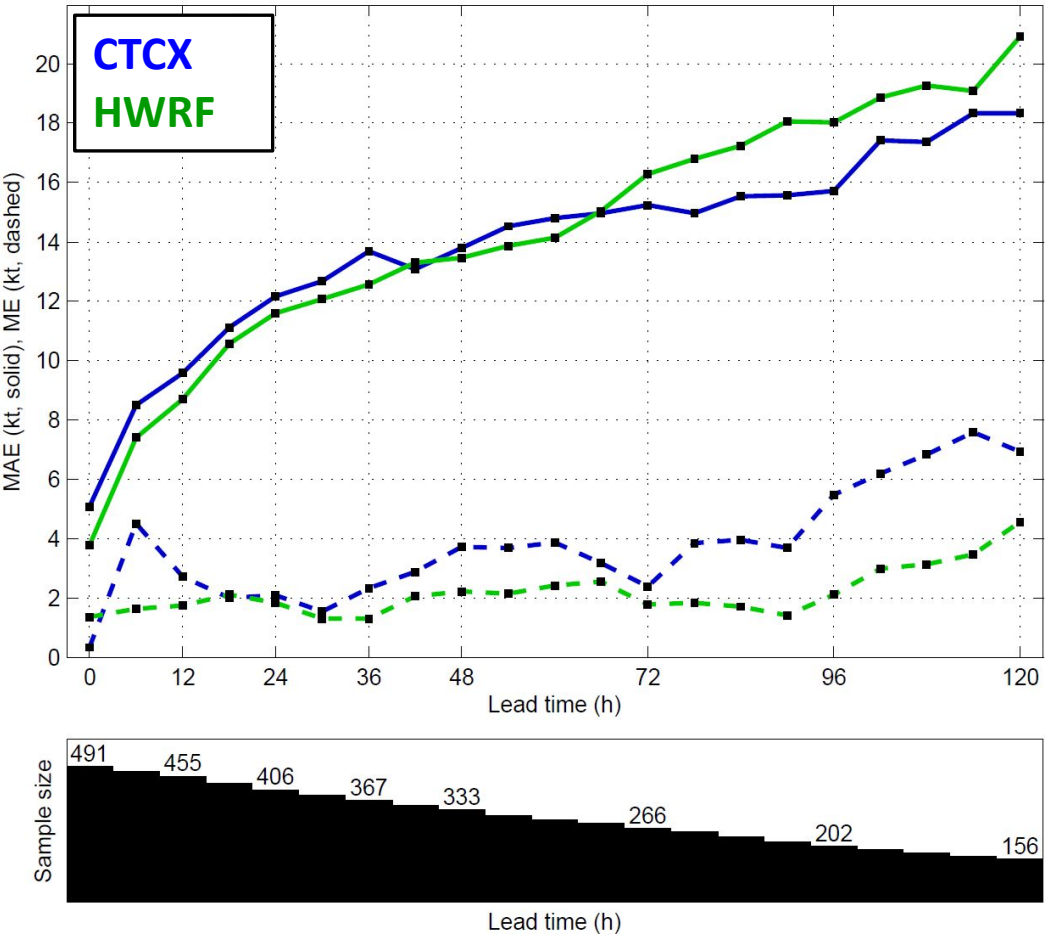Dorian (05L) (12Z 1 Sep 2019)
SSTs and 10-m Winds

COAMPS-TC Performance
Western North Pacific Basin 2021

2021 Track Mean Absolute Error (nm)

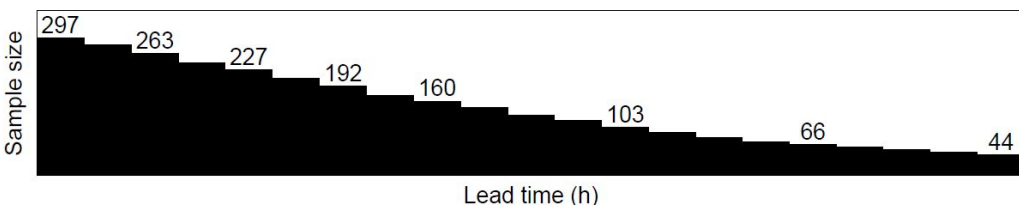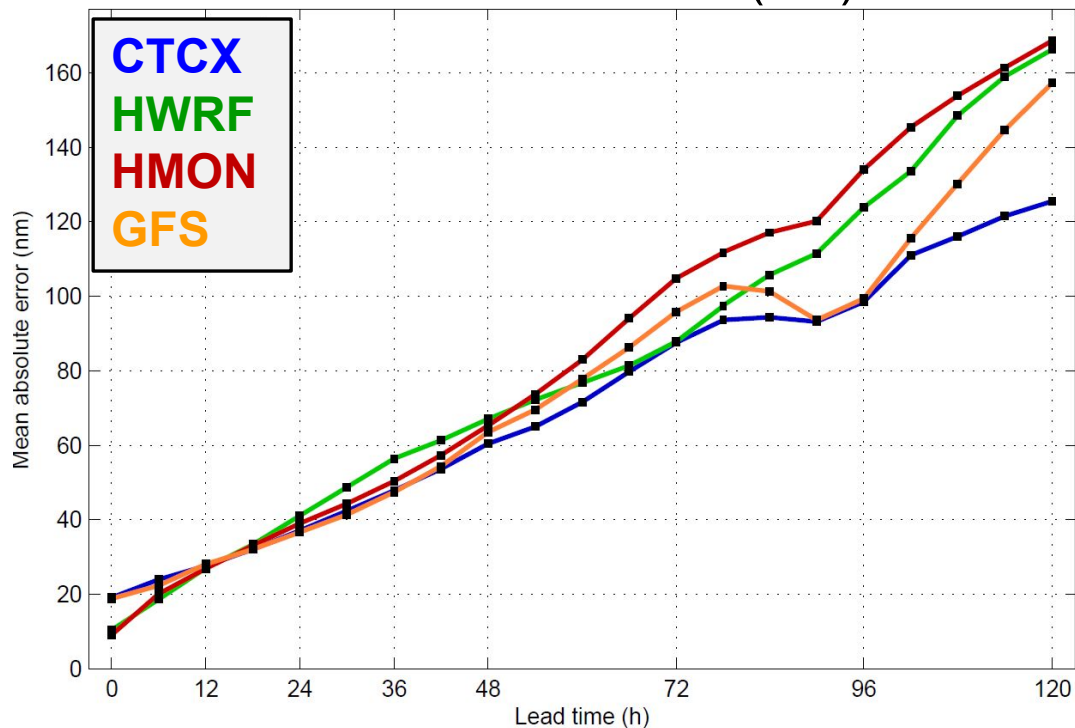### 2021 Intensity MAE (solid) and ME (dashed)

- CTCX track error is much improved for 72-120h in 2021 and similar to HWRF and GFS
- CTCX intensity MAE is similar to HWRF 0-72h, and lower MAE 72-120h

COAMPS-TC Performance
Eastern North Pacific Basin 2021

U.S. NAVAL RESEARCH LABORATORY

Track Mean Absolute Error (nm)

CTCX
HWRF
HMON
GFS

Intensity MAE (solid) and ME (dashed)
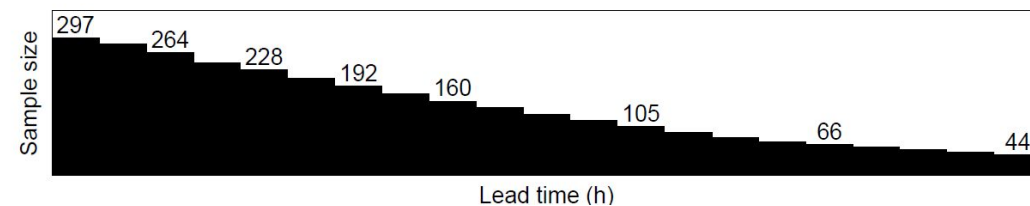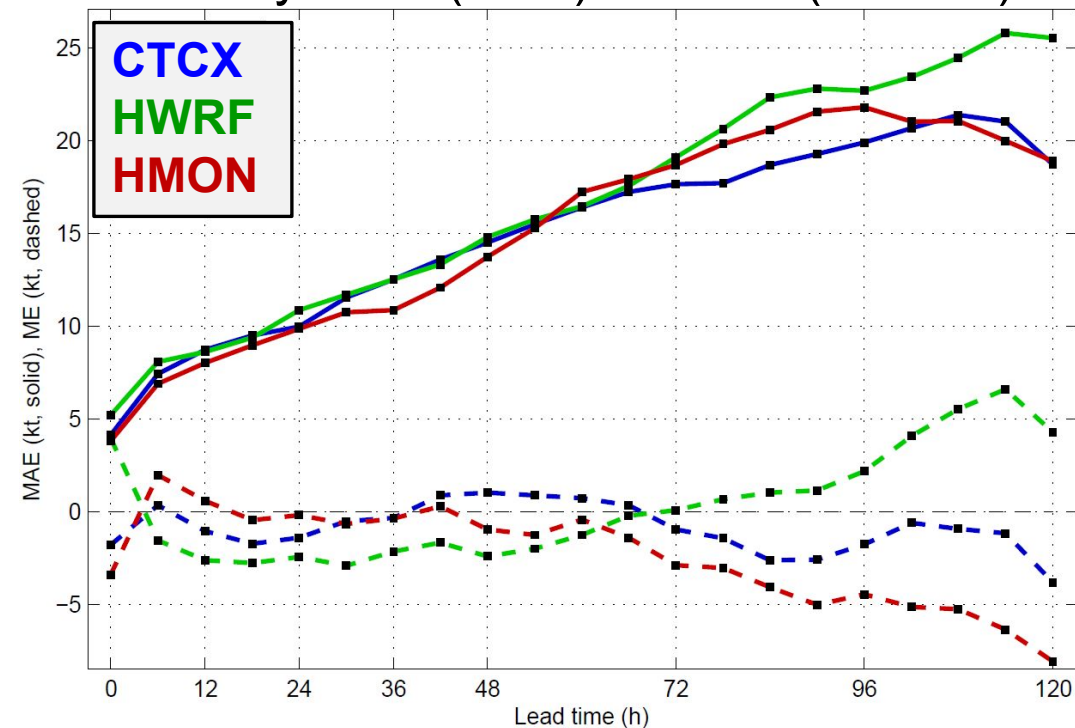
CTCX
HWRF
HMON

- CTCX track error is generally lower than GFS, HMON, HWRF
- CTCX intensity MAE is similar to HWRF 0-72h, and lower MAE 72-120h

COAMPS-TC Performance
Atlantic Basin 2020-2021

2021 Track Mean Absolute Error (nm)
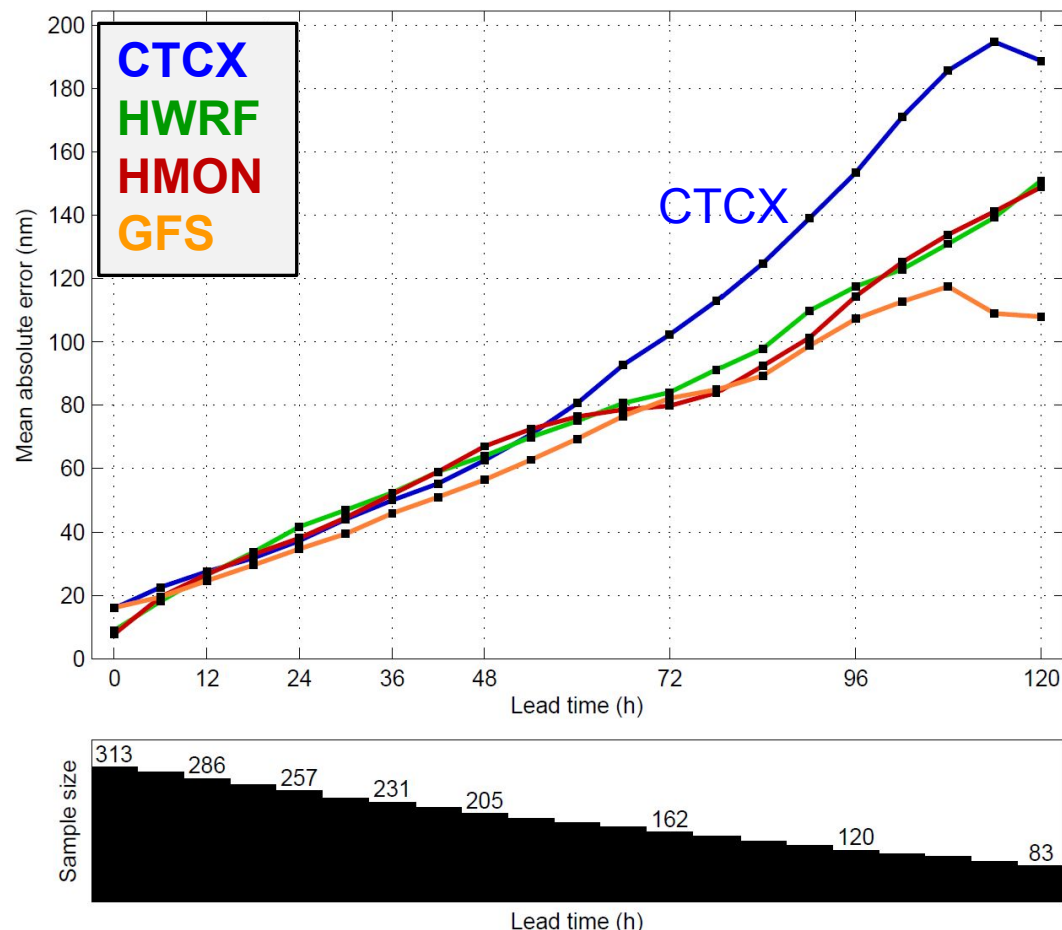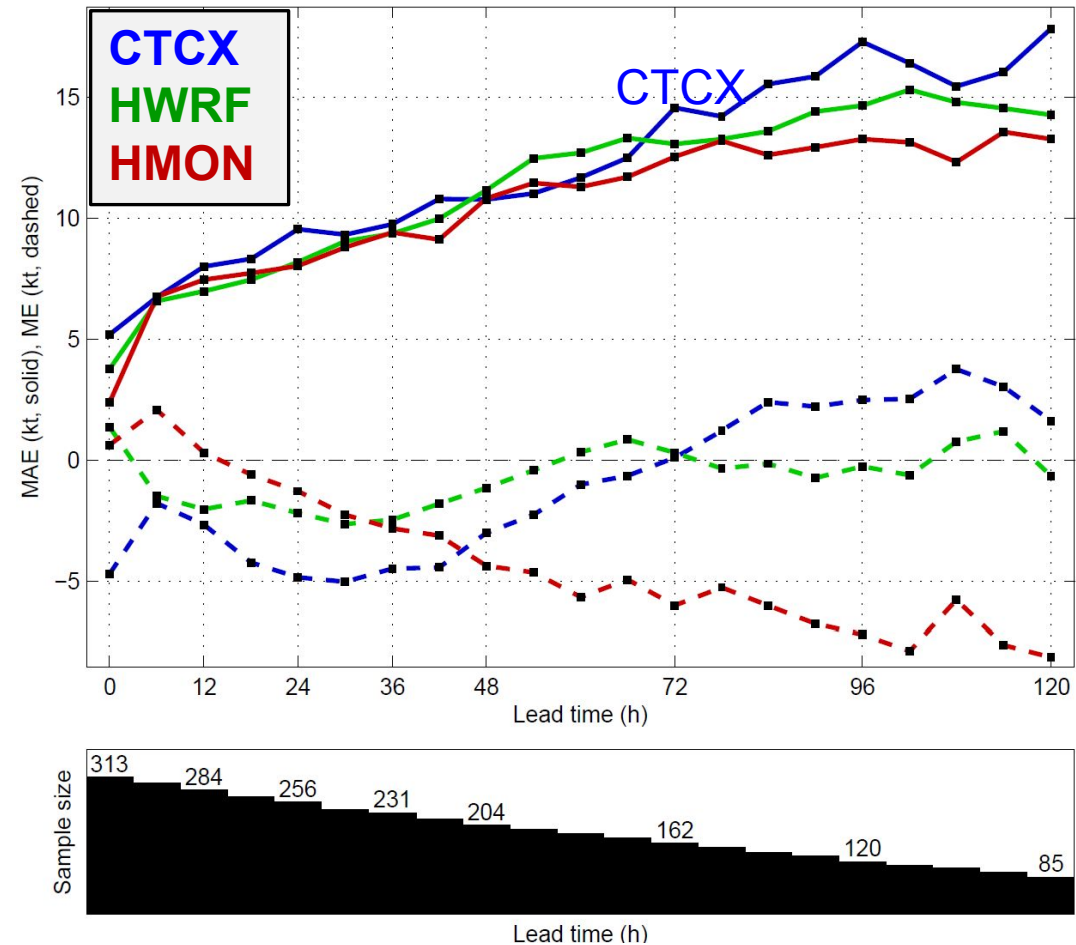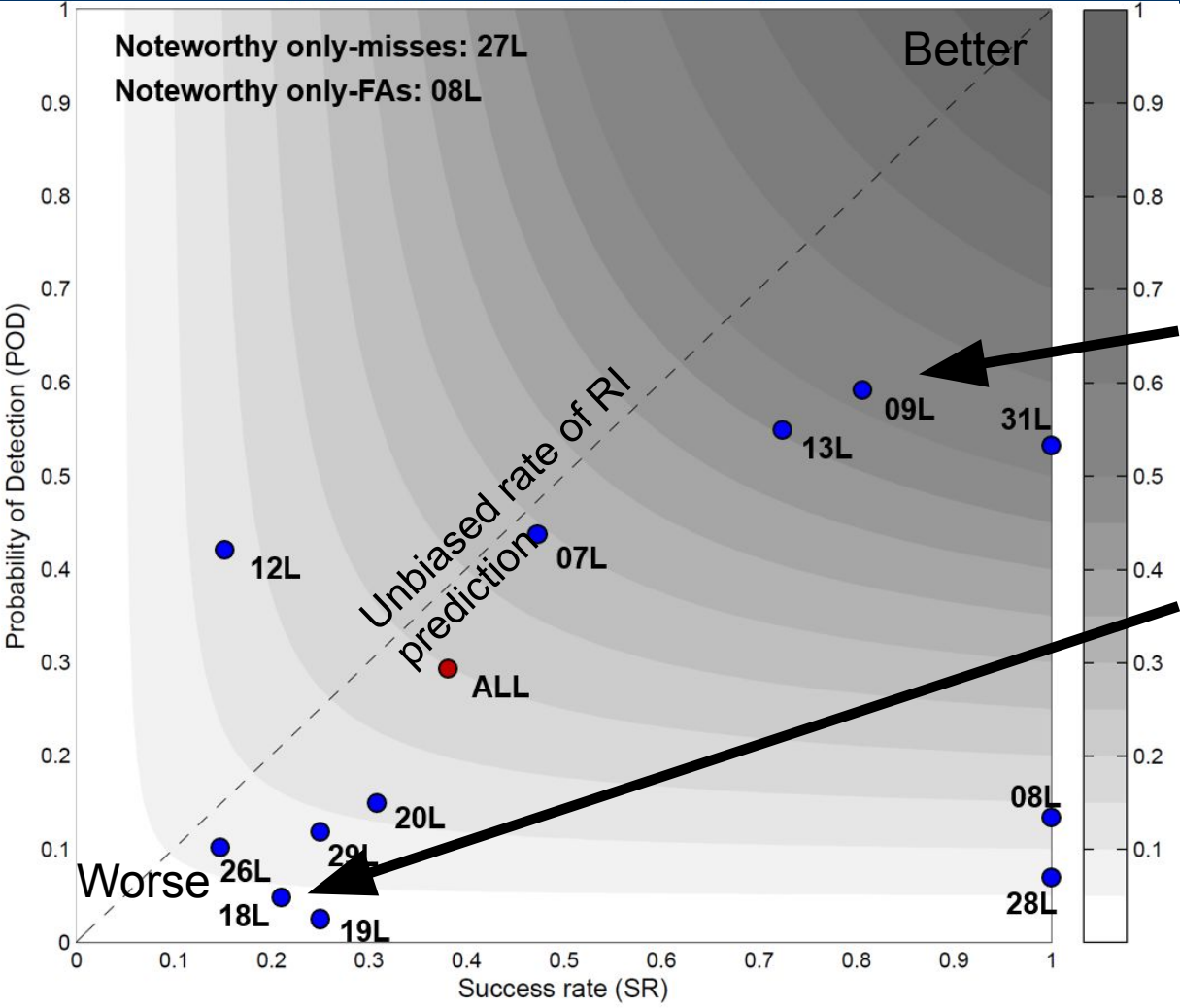

2021 ATL Intensity MAE (solid) and ME (dashed)

- Low track error for CTCX in 2020; CTCX virtually the same in 2021, yet track errors were worse
- Intensity errors similar to HWRF and HMON to 72h and trailed other models after by 1-2 kts.

U.S. NAVAL RESEARCH LABORATORY

2020/2021 Atlantic Storm-by-Storm RI performance

2020 TCRI storms
- 19L: Sally
- 20L: Teddy
- 26L: Delta

2021 TCRI storms
- 07L: Grace
- 08L: Henri
- 09L: Ida
- 18L: Sam

The best CTCX RI forecasts are for storms with a prolonged period of RI with peak rate >= 55 kt / 24 h, and peak intensity >= Cat4. Ida (09L) is an example, as is the GoM intensification of Grace (07L)
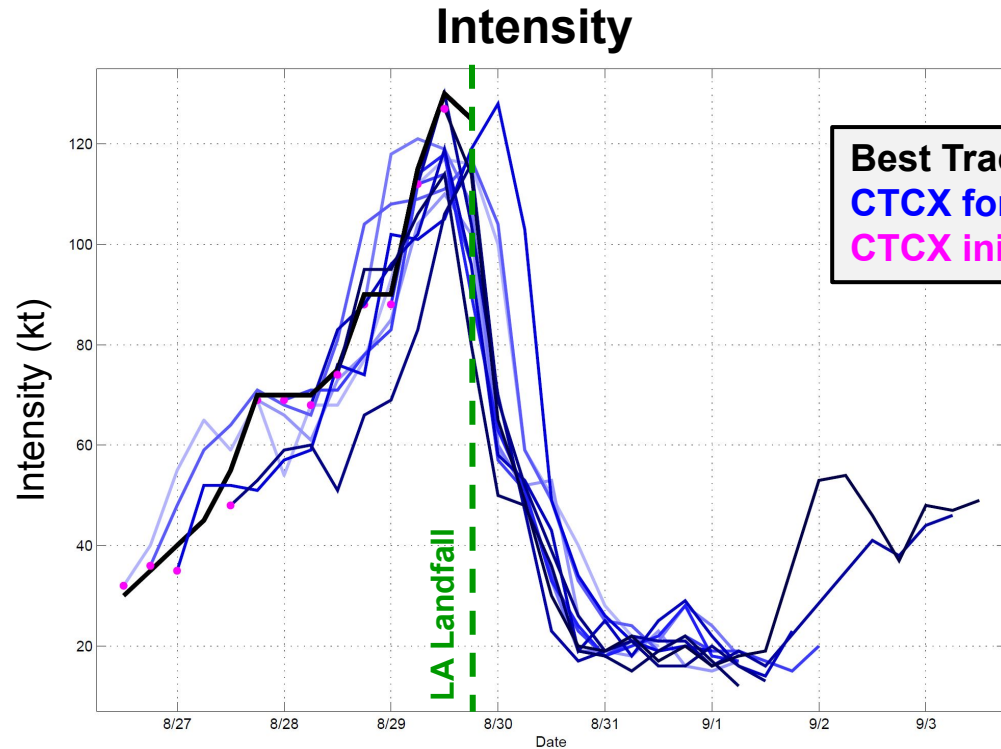
CTCX does not make great RI forecasts for all storms as described above, however. Poor forecasts were made for Delta (26L) and Sam (18L), which both had a very small inner core.

Henri (08L) was an unusual case in which CTCX consistently predicted RI but it did not occur

Threat score is shaded (higher = better), unbiased rate of RI prediction along diagonal

Moskaitis

COAMPS-TC: Hurricane Ida
2021 Atlantic Storm 09L

Intensity

Track

Best Track (thick line)
CTCX forecasts (lines)
CTCX initial positions (dots)

Starting 48 h prior to landfall, CTCX accurately predicted the exact landfall time and position

All CTCX forecasts indicated a peak intensity of at least 110 kt just prior to landfall, even when the initial intensity was just 30 kt

Best Track
Best Track position at 29/18z
CTCX forecasts
CTCX forecast positions valid at 29/18z
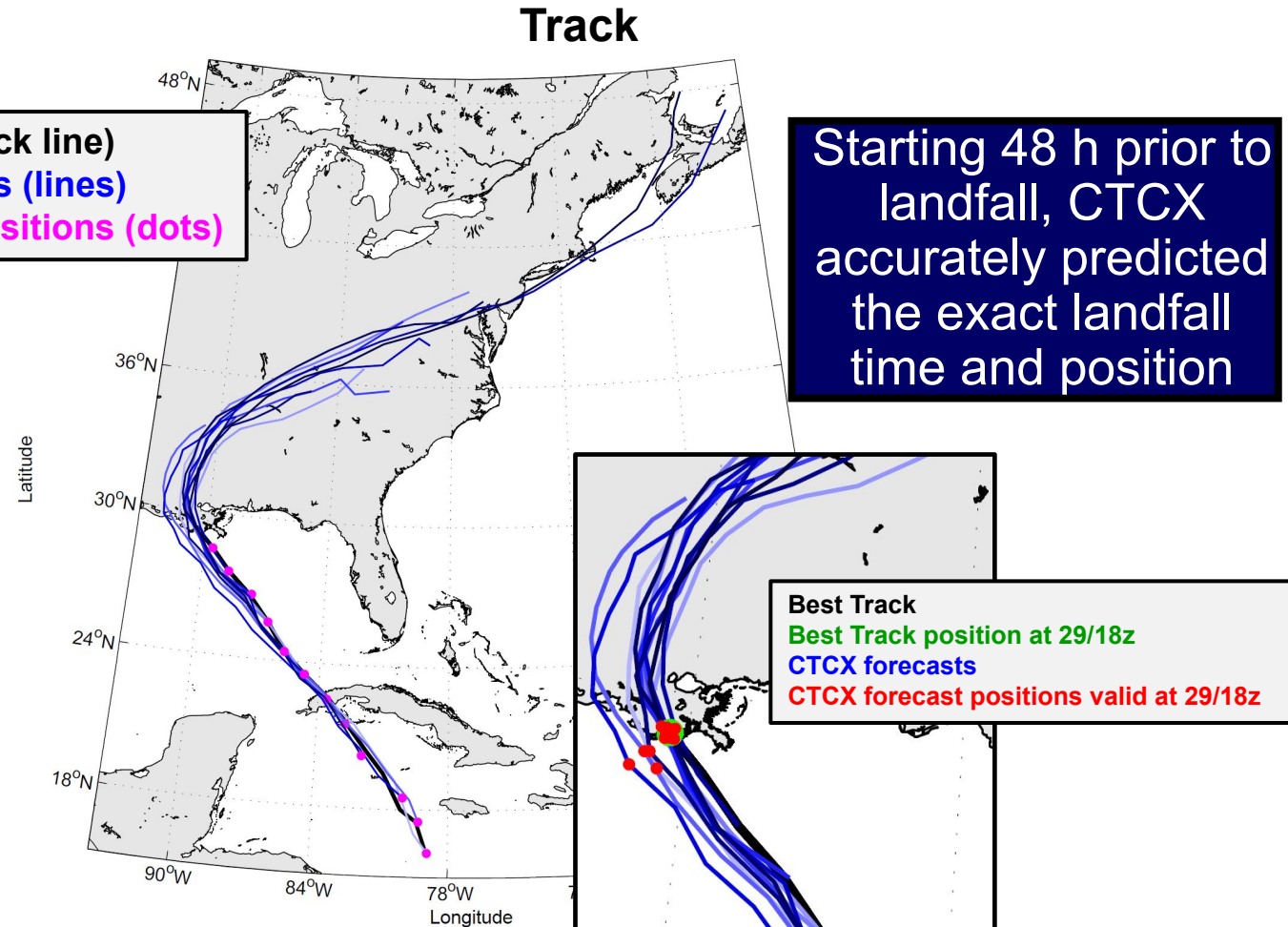
CTCX RI and track forecasts for Hurricane Ida (13L) were amazingly accurate, very similar to those for Hurricane Laura (2020)

U.S. NAVAL RESEARCH LABORATORY

CTCX Ensemble System Configuration

- 11 members in operations, 21 members in demo mode
- 36/12/4 km grid, moving nests
- Perturbed synoptic-scale initial conditions (ICs), boundary conditions (BCs), vortex initial intensity, and drag coefficient

New in v2021 (soon to be operational at FNMOC)

- Physics updates (shallow convection, microphysics, C_D)
- Now running Invests
- Adjusted IC/BC perturbation magnitudes
- GFS downscaling for weak TCs, modified vortex for strong TCs
- Improved parameterized 1-D SST cooling
- Modified nested grids (improves track performance)

Hurricane Ida (09L)

TC = 09L, DTG = 2021082700
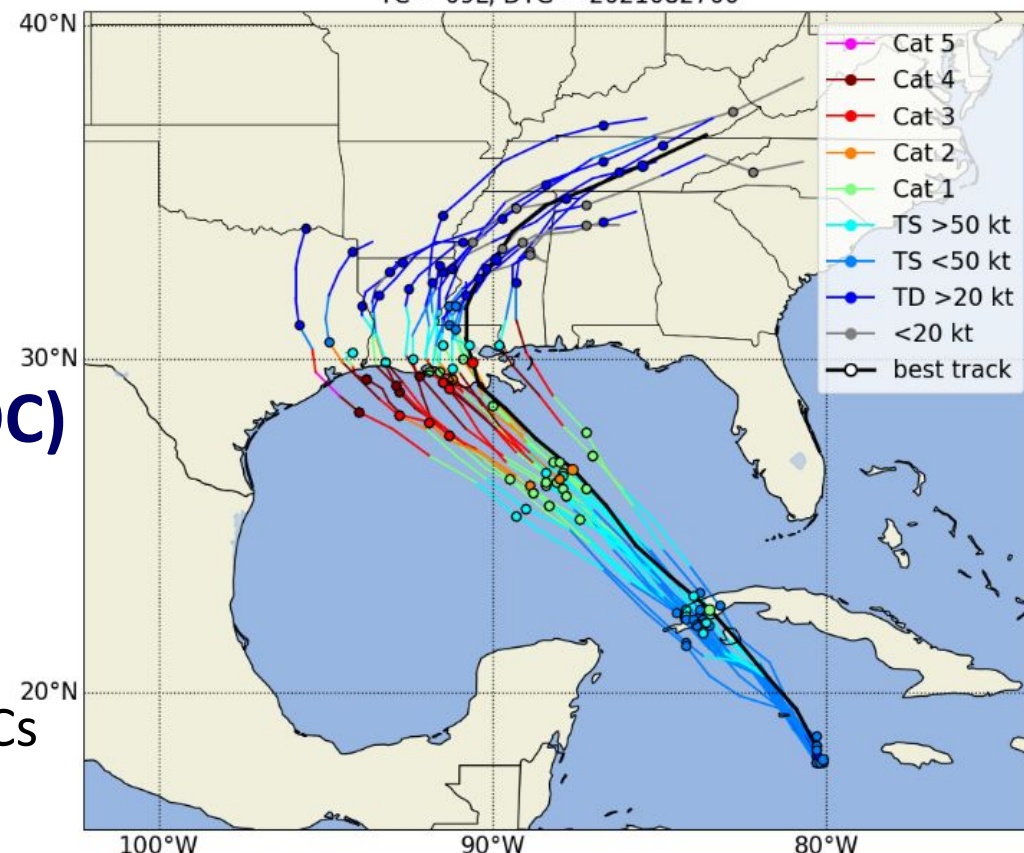
Legend:
- Cat 5
- Cat 4
- Cat 3
- Cat 2
- Cat 1
- TS >50 kt
- TS <50 kt
- TD >20 kt
- <20 kt
- best track
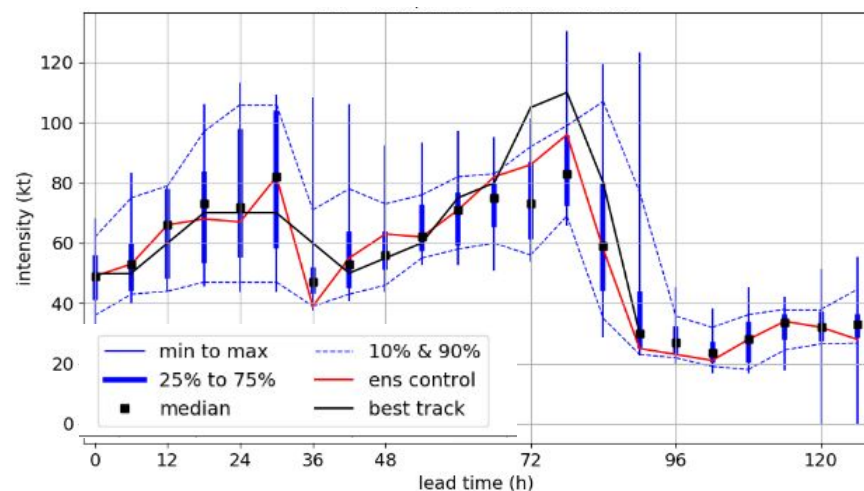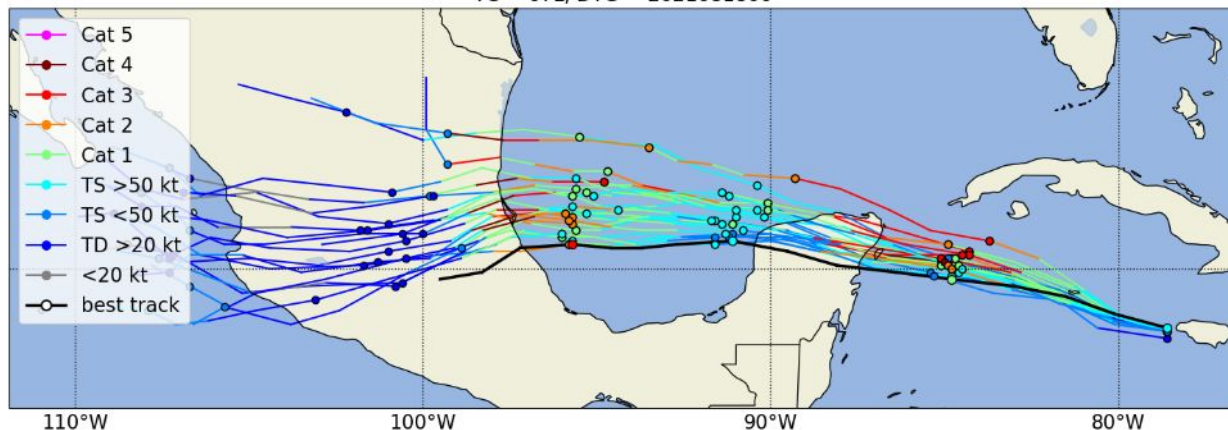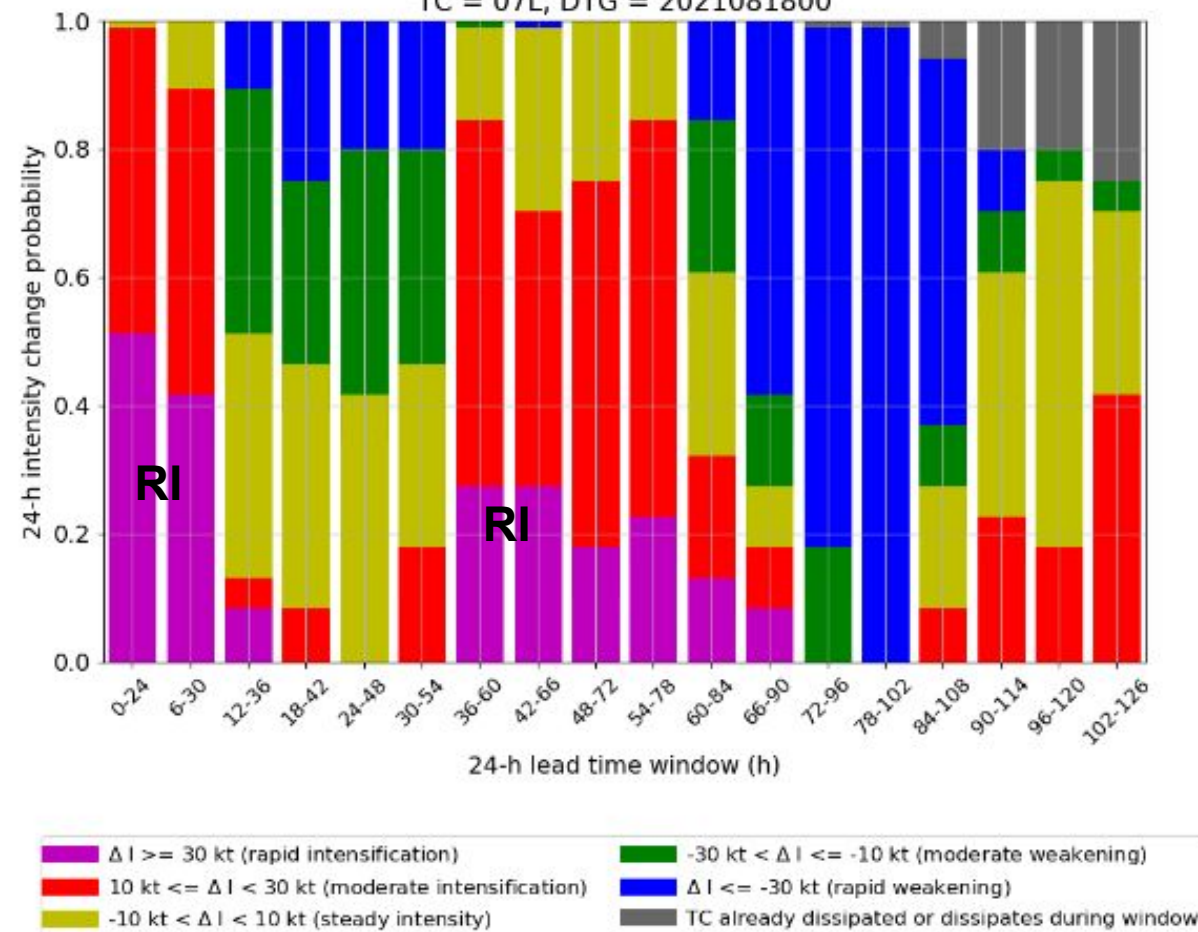
- Observed track at the southern edge of ensemble distribution
- Two separate periods of intensification, with ~50% and ~30% probabilities of RI (respectively), interrupted by land interaction

COAMPS-TC Improvements
Future Upgrades

Microphysics Parameterization
Hurricane Dorian Simulated Radar Reflectivity (36h)

Control

Morrison

Thompson

- Substantial differences among NRL (Control), Thompson, Morrison microphysics.
- Other new params. being tested include PBL, deep/shallow cumulus.
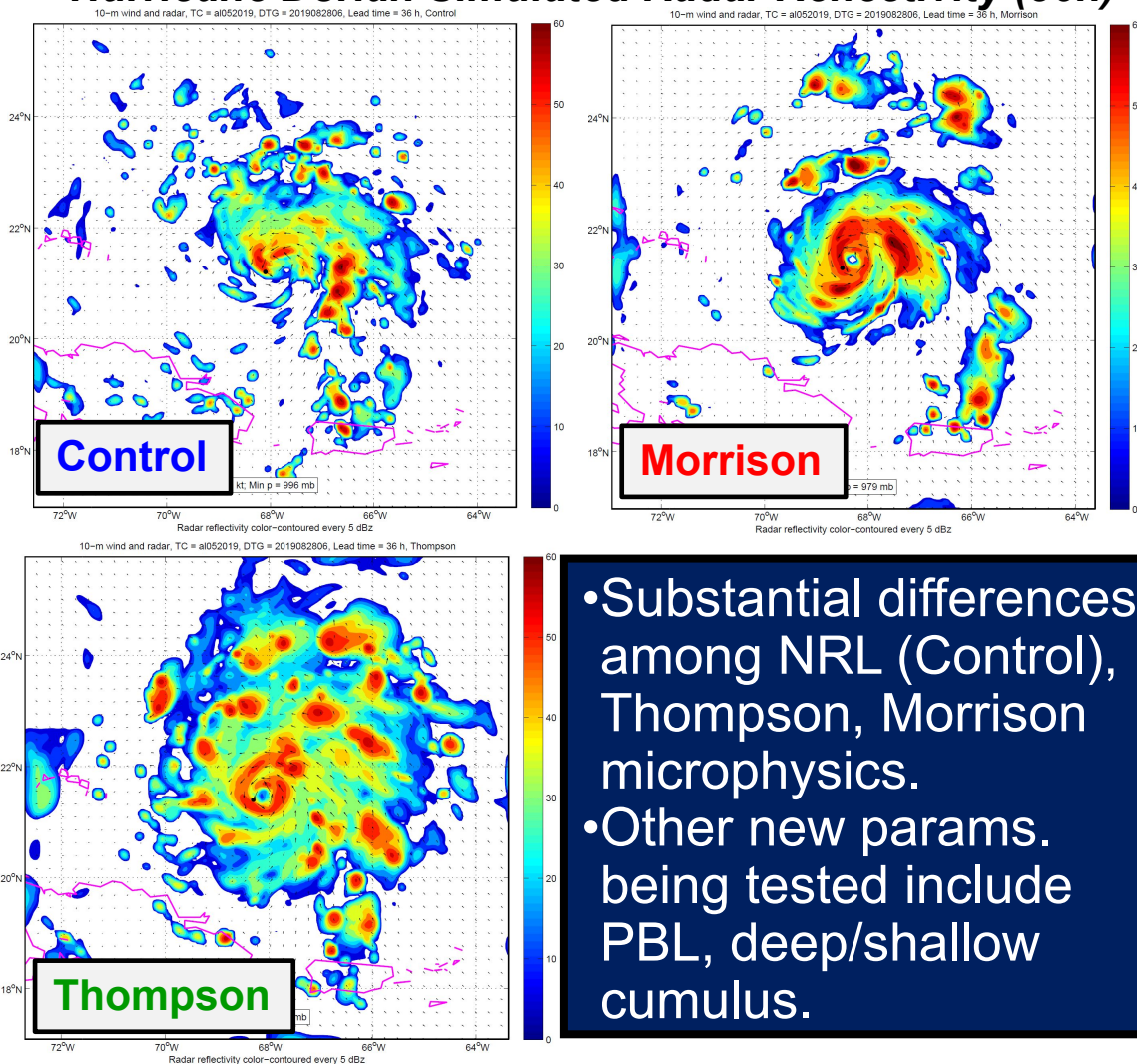
All Sky Radiance Assimilation
Hurricane Patricia (2015) Assimilation Experiments

Satellite Radiance Observations

No Satellite DA

All Sky DA
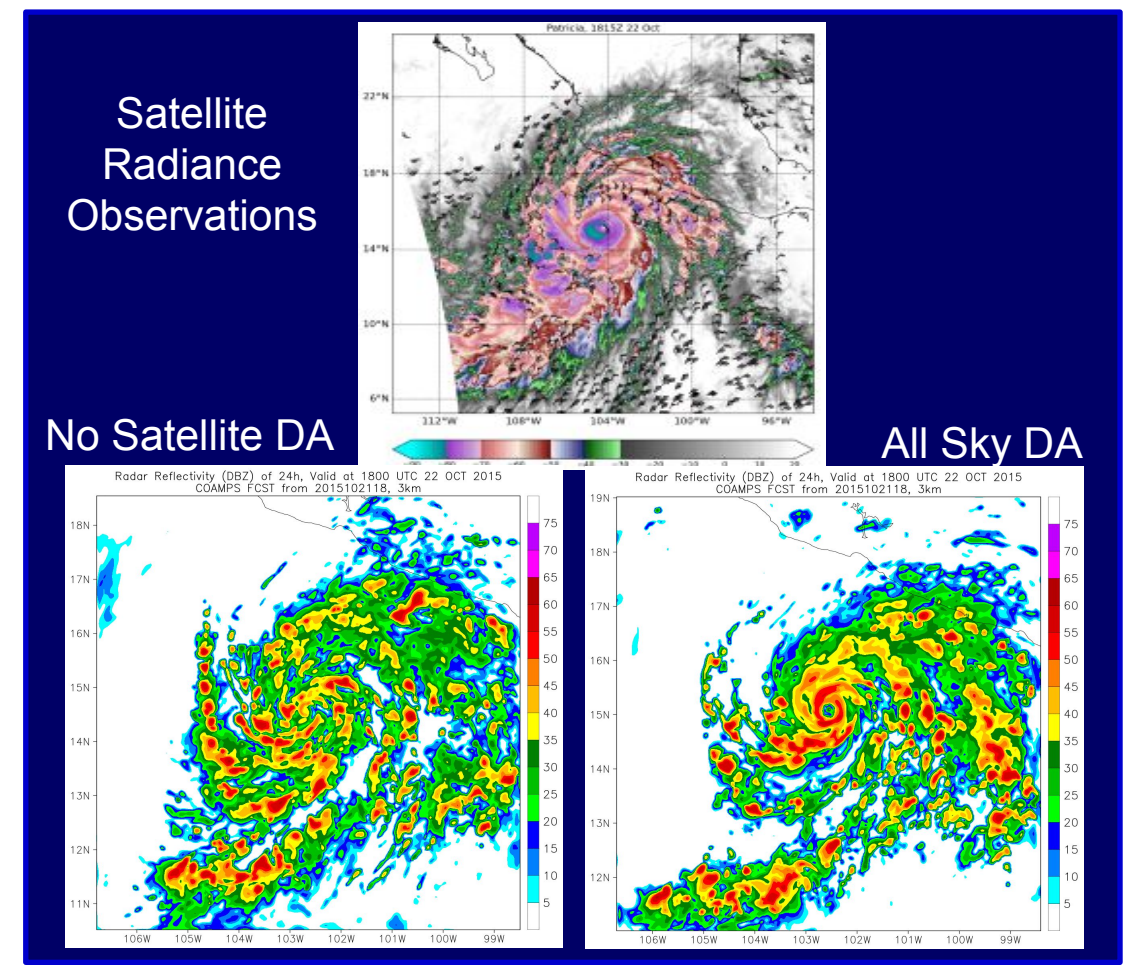
COAMPS-TC includes EnKF & CRTM (w/ PSU)

Yi Jin

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Zhao and Jin

U.S. NAVAL RESEARCH LABORATORY

- Navy ESPC: fully coupled subseasonal model
- 45 day forecasts; 16 members; once weekly
- NAVGEM (37km); HYCOM & CICE (~8km)
- Specialized TC products including wind shear

- NEPTUNE: uses a spectral element dynamical core that is highly scalable and accurate (4th order)
- Utilizes Common Community Physics Package
- Unified model with regional, global, high-altitude
- Mesh refinement (static and adaptive) (future)

UNCLASSIFIED
Navy ESPC Ensemble (16 Members)
Shading: 850-200 hPa Wind Shear Magnitude Anomaly
Vectors: 850-200 hPa Wind Shear Vector Anomaly
Contours: 850-200 hPa Total Wind Shear Magnitude
Green = 5 m s^{-1} (Favorable)   Yellow = 10 m s^{-1} (Neutral)   Red = 15 m s^{-1} (Unfavorable)
Week 2 Average: 2021/10/18 - 2021/10/24   15 m s^{-1} →
Approved for public release; distribution unlimited.
UNCLASSIFIED

High shear – unfavorable
Moderate shear – neutral
Low shear - favorable

Matt Janiga

Real-Time Testing (120h)
6-h Accumulated Precipitation

Alex Reinecke

Mesh Refinement
Static and Adaptive

Hendricks et. al. 2015

Summary and Key Gaps

- COAMPS-TC much improved for RI, Intensity, Track over last few years
    - ◻ COAMPS-TC 2022 deterministic: important software upgrade (no meaningful change to skill)
    - ◻ COAMPS-TC 2022 ensemble: upgrade to physics similar to deterministic (in operations testing).
    - ◻ 2023 Upgrades: Higher horizontal & vertical resolution, new physics (cumulus, microphysics, PBL)
- Navy ESPC (coupled subseasonal) and NEPTUNE (next-gen) global model
- Continue to use TC observations to inform model development (ONR TCI, TCRI etc.)
    - Gaps
        - ◻ Challenges remain with predicting rapid intensification. CTCX now has sufficient skill for RI that some cases are reasonably captured (e.g. Ida, Laura), but others storms remain a struggle. Research being conducted under the ONR TC Rapid Intensification program should help.
        - ◻ COAMPS-TC ensemble was an excellent tool for probabilistic track and intensity prediction in 2020-21. A few challenging cases each season where verifying track and intensity falls outside ensemble.
        - ◻ Track errors in CTCX occur more frequently when storms interact with islands and terrain (e.g., Caribbean), particularly when the storms are weak.